DETECTION AND CORRECTION OF STEP DISCONTINUITIES IN KEPLER FLUX TIME SERIES.

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Introduction: PDC 8.0 includes an implementation of a new algorithm to detect and correct step discontinuities appearing in roughly one of every 20 stellar light curves during a given quarter. The majority of such discontinuities are believed to result from high-energy particles (either cosmic or solar in origin) striking the photometer and causing permanent local changes (typically -0.5%) in quantum efficiency, though a partial exponential recovery is often observed [1]. Since these features, dubbed sudden pixel sensitivity dropouts (SPSDs), are uncorrelated across targets they cannot be properly accounted for by the current detrending algorithm. PDC detrending is based on the assumption that features in flux time series are due either to intrinsic stellar phenomena or to systematic errors and that systematics will exhibit measurable correlations across targets. SPSD events violate these assumptions and their successful removal not only rectifies the flux values of affected targets, but demonstrably improves the overall performance of PDC detrending [1].

Algorithm: The algorithm consists of three components: filtering, detection, and correction. The design of the LSI detection filter is based on the method of Savitzky and Golay [2] with an added multi-scale analysis step to improve localization of the peak response. Detection and correction are performed on all targets in a given channel in an iterative process whereby the maximal detector response for each target is evaluated and, if an SPSD is detected, a correction is applied. For the current iteration, targets in which SPSDs were found and corrected are retained in a list and the process is repeated until the list is empty.

Detection. The detection step begins with preconditioning of each time series by filling gaps and padding endpoints. Conditioned time series are then convolved with the detection filter and responses are normalized across all targets and cadences on the current channel. The maximum normalized detector response for each target is evaluated by applying succession of threshold-based decisions to determine first whether it is a feasible candidate and finally whether it should be labelled an SPSD.

Correction. Correction is a two stage process. The first stage estimates a persistent step height from analysis of the entire flux time series, excluding a short recovery window following the SPSD, which typically contains a transient signal. The second stage models the recovery window using a series of exponentials of varing time constant. The algorithm also detects and preserves sinusoids in the signal while removing only the step and recovery transient components.

Results: The algorithm has been tested on (1) Q7 flight data containing signatures of real SPSD events, and (2) Q7 flight data with SPSD-affected targets removed and 100 simulated SPSDs injected into the time series of ~12th magnitude targets ($11.5 \leq m \leq 12.5$). Detection performance on flight data was estimated at P(hit)=0.89 and P(false alarm)=0.007, relative to manual SPSD identification for a single channel (1912 light curves). Performance on simulated SPSDs is shown in figure 2 as a function of the magnitudes of injected sensitivity drops.

References: [1] J. M. Jenkins, et al. (2010) *ApJ, 713*, L87. [2] A. Savitzky and M. Golay (1964) *Analytical Chem., 36 (8)*, 1627-1639.

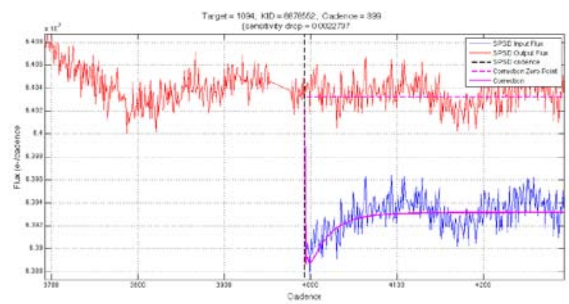

Figure 1. Example of a typical discontinuity and its correction (channel 13.1, Q7).

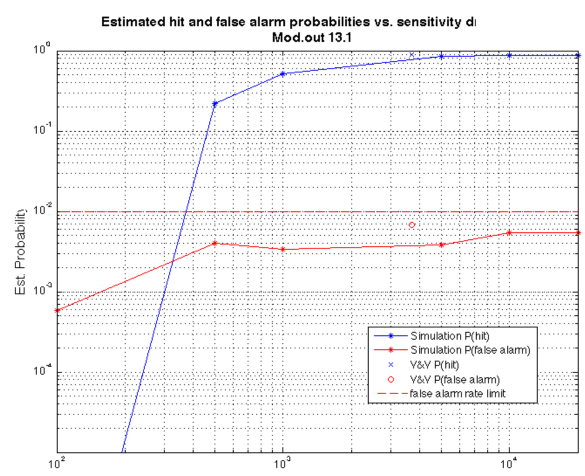

Figure 2. Detection performance vs. simulated sensitivity drop (channel 13.1, Q7).